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PCT/NZ03/00204

REC'D 15 OCT 2003
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CERTIFICATE

This certificate is issued in support of an application for Patent registration in a country outside New Zealand pursuant to the Patents Act 1953 and the Regulations thereunder.

I hereby certify that annexed is a true copy of the Provisional Specification as filed on 31 October 2002 with an application for Letters Patent number 522310 made by FISHER & PAYKEL HEALTHCARE LIMITED.

Dated 29 September 2003.

Neville Harris

Neville Harris
Commissioner of Patents, Trade Marks and Designs

COMMISSIONER OF PATENTS, TRADEMARKS & DESIGNS
NEW ZEALAND

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522310

NEW ZEALAND

PATENTS ACT, 1953

PROVISIONAL SPECIFICATION

"Conduits"

We, FISHER & PAYKEL HEALTHCARE LIMITED a company duly incorporated under the laws of New Zealand of 15 Maurice Paykel Place, East Tamaki, Auckland, New Zealand, do hereby declare this invention to be described in the following statement:

Intellectual Property Office of NZ

31 OCT 2002

RECEIVED

BACKGROUND TO THE INVENTION

Field of the Invention

The present invention relates to components for breathing circuits and in particular to conduits for use in the limbs of breathing circuits. The invention also relates to methods of manufacturing such conduits.

Summary of the Prior Art

In assisted breathing, particularly in medical applications, gases are supplied and returned through conduits. Such conduits are ideally light and flexible to ensure the greatest level of comfort for the patient. In the prior art, thin walled conduits are known which include helical or annular reinforcing ribs which act to give the conduit better resistance to crushing and pinching, while still allowing the conduit to be light and flexible. An example of one such conduit is shown in Figure 1.

It is advantageous to manufacture this type of conduit as a continuous process. In the prior art this is achieved by spiral winding of a thin polymer tape onto a former such that the edges of adjacent layers overlap a small amount. A bead of molten polymer is then applied over the top of the overlapping edges welding them together and simultaneously forming the helical reinforcing ribs. A disadvantage with this forming technique is the difficulty welding several adjacent layers. This problem is especially severe when multiple layer conduit walls are to be formed. While combining the application of a molten bead with another secondary thermal welding process or applying the polymer to the former as a still molten plastic does go some way to alleviating this difficulty, these solutions add complexity to the tube former and may be difficult to achieve with very thin walls.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a conduit, with particular application to the limbs of a breathing circuit, which will at least go some way towards improving on the above or which will at least provide the public and the medical profession with a useful choice, and/or to provide a method of manufacturing a conduit which will at least go some way towards providing the public and manufacturers with a useful choice.

In a first aspect the invention may broadly be said to consist in a method of preforming an infinite length of a ribbon of film for use in the manufacture of a conduit comprising:

taking a film of ribbon and folding said ribbon substantially in half,

heating said folded ribbon and forming a crease substantially midway along the width of said ribbon.

Preferably said preformed ribbon is rolled onto a spool for later use.

Preferably when said ribbon is folded substantially in half, at least one length of conductive material is encapsulated within said folded ribbon.

Preferably said at least one length of conductive material is encapsulated at the fold line of said folded ribbon.

Preferably said at least one length of conductive material is two wires, the first of said two wires encapsulated along said fold line and the second of said two wires spaced a predetermined distance from said first wire.

Alternatively when said ribbon is folded substantially in half, at least one length of insulative material is encapsulated within said folded ribbon.

Preferably said insulative material is a continuous length of foam material.

In a further aspect the invention may broadly be said to consist in an apparatus to preform an infinite length of ribbon of film for use in the manufacture of a conduit comprising:

folding means capable of receiving and folding said ribbon of film substantially in half,

heating means to receive said folded ribbon and heat said ribbon,

creasing means to receive said folded and heated ribbon and form a crease in said ribbon.

Preferably said folding means includes means to receive at least one conductor and encapsulate said at least one conductor within said folded ribbon.

Preferably said at least one conductor is two wires and said folding means being capable of receiving said two wires and encapsulating the first of said two wires along

the fold line as said ribbon is folded and encapsulating the second of said two wires spaced at a predetermined distance from said first wire.

Alternatively said folding means includes means to receive at least one length of insulative material and encapsulate said at least one length of insulative material within said folded ribbon.

Preferably said at least one length of insulative material is a length of a foam material.

In a still a further aspect the invention may broadly be said to consist in a method of forming a continuous conduit comprising:

applying at least one preformed film of ribbon, each having leading and trailing lateral edges, spirally around a former, with the leading edge of each turn of ribbon overlapping the trailing edge of the previous turn of said ribbon on the former and the trailing edge of each turn overlapping the leading edge of the succeeding turn, and

applying a bead of molten plastic along the overlapping of said leading and trailing edges.

In an alternative embodiment the ribbon may include one or more conductors embedded within or along its trailing edge. The conductors may be extruded into the ribbon or alternatively the ribbon may include a longitudinal fold with the conductors disposed within the fold adjacent the fold.

In yet still a further aspect the invention may broadly be said to consist in a conduit comprising:

at least one thin plastic ribbon having a leading and a trailing lateral edge, said ribbon arranged helically with its face substantially parallel with the helix axis, and, apart from at its ends, the leading edge of each turn of ribbon overlapping the trailing edge of a previous turn, and the trailing edge of each turn of ribbon underlapping the leading edge of a succeeding turn,

a plastic reinforcing bead disposed over each overlapping leading and trailing edge.

Preferably said trailing edge has at least one conductive element encapsulated within it.

Preferably said at least one conductive element is two wires, the first of said two wires encapsulated along said fold line and the second of said two wires spaced a predetermined distance from said first wire.

Preferably said bead is substantially semi-circular in shape but having a concave underside.

In one embodiment said ribbon may be a non-breathable plastic material.

In another embodiment said ribbon may be a breathable plastic material.

In a still further aspect the invention may broadly be said to consist in apparatus for forming a conduit comprising a former for receiving at least one plastic ribbon, said former drawing said ribbon around and advancing said ribbon along to procure a helical arrangement of said ribbon, where said at least one ribbon has leading and trailing lateral edges that overlap as said at least one ribbon is advanced along said former, the pitch of said helical arrangement being somewhat less than the width of said ribbon,

means for delivering a ribbon to said former at a first position on said former, and

means for continuously delivering a molten bead to said former at a position less than one turn pitch from the position of delivery of said ribbon said position corresponding to an expected position of the overlapping edges of said ribbon delivered by said means for delivering a ribbon.

Preferably said ribbon is a folded ribbon that has had at least one conductor encapsulated along the trailing edge of said folded ribbon, and said bead covers said at least one conductor.

To those skilled in the art to which the invention relates, many changes in construction and widely differing embodiments and applications of the invention will suggest themselves without departing from the scope of the invention as defined in the appended claims. The disclosures and the descriptions herein are purely illustrative and are not intended to be in any sense limiting.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a cross sectional side elevation of a conduit according to an embodiment of the prior art.

Figure 2 is a flow diagram of the preforming of a film of plastic to be used in the manufacture of a conduit of the present invention.

Figure 3 is a cross sectional view of preforming a film, including a pair of heater wires, for use in forming the conduit of the present invention.

Figure 4 is a cross sectional assembly view of a pair a heater wires being embedded in the film.

Figure 5 is a cross sectional assembly view of a folded film with a crease formed in it.

Figure 6 is a cross sectional view of a conduit including a pair of heater wires formed from the preformed film as shown in Figure 4.

Figure 7 is a cross sectional elevation of a conduit according to the present invention having outer reinforcing bead.

Figure 8 is a plan view of a conduit forming device for forming a conduit of the present invention.

Figure 9 is a flow diagram of the steps in the method of manufacturing a conduit of the present invention.

Figure 10 is a side view of the apparatus used to form the preformed film of the present invention.

Figure 11 is a side view of the apparatus used to form the conduit of the present invention.

Figure 12 is a cross sectional view of the reinforcing bead extruded onto the conduit of the present invention.

DETAILED DESCRIPTION OF THE PRIOR ART

The present invention relates to breathing conduits in general and in particular to improved methods of forming thin film spiral wound conduits. Consequently the present invention finds application in breathing conduits fabricated from a variety of materials which may include breathable and/or non-breathable materials (breathable materials being capable of transmitting water vapour).

Continuous Positive Airway Pressure (CPAP) systems or positive pressure ventilation systems that provide patients suffering from obstructive sleep apnoea (OSA)

with positive pressure gases often use conduits similar to the prior art described. Often in these applications and in other medical applications, such as with assisted breathing, gases having high levels of relative humidity are supplied to patients and sometimes returned through conduits of a relatively restricted size. The aim of the present invention is to provide an alternative conduit that will withstand the stresses of high use, that is being flexible, yet not prone to breakage under axial stretching or movement.

The preferred conduits of the present invention are formed from a non-breathable material, such as a polymer plastic block formed into a homogeneous flat film. An example of such a film is sold under the brand EVOLUE.

In alternative forms of the conduit of the present invention a conduit may be formed from a breathable material, such as a hydrophilic polyester block copolymer formed into a homogeneous flat film. An example of such a film is sold under the brand SYMPATEX.

The following embodiments will be described with particular reference to non-breathable thin film wall construction from materials such as EVOLUE. It will be appreciated however, that in the following described embodiments the material used to form the conduit walls may be either breathable or non-breathable and may also include combinations of both breathable and non-breathable materials. It will be also appreciated for the following described embodiments that the film formed during the preforming stage of the method of the present invention, may be supplied either as a preformed film wound on to a spool or may alternatively be supplied directly from an extruder. It will also be appreciated by those skilled in the art that the materials supplied to a former used in the manufacture of the conduit may require guides and/or rollers in order to position the film accurately and provide the necessary tension.

It is preferred that the conduit wall be manufactured to have a relatively low wall thickness, so much so that the conduit wall membrane may be insufficiently sturdy to be self supporting. Spiral or helical reinforcing members are therefore provided as part of the tubular wall membrane to provide support. The helical or spiral supporting

members are formed from polymer plastic materials and may be of the same material used in the wall of the conduit or any other compatible plastics material.

Referring to Figure 1, the lay-up arrangement of a flexible breathing conduit known in the art is shown.

Preforming of Film

The first step in the manufacture of the conduit of the present invention is the forming of a folded plastic film. The film may be formed with or without at least one integral electrical conductor. In other forms of the preformed film, the film may be formed with other material in place of the electrical conductor or conductors, such as a foam strip, a strip of conductive film or other conductive or insulative materials. The description following describes only one such form of the folded plastic film, that with at least one integrally formed conductor.

Referring to Figures 2 to 5 and 10, a method of forming a plastic film with two parallel conductors and plastic film so formed are illustrated. Firstly, a plastic film 2, such as EVOLUE film, is supplied on a spool 1. Two electrical conductive wires 4, 5 are supplied on two spools 6. The film 2 and two wires 4, 6 are simultaneously drawn from their respective spools 1, 6 and fed into the film folder 3. The film folder 3 preferably folds the film 2 in half with the two wires 4, 6 running down the centre fold (X in Figures 3 and 4) in the film 2. Figure 3 shows the film 2 and two wires 4, 6 prior to being fed into the film folder where the wires are fed above the film 2. The arrow in Figure 3, indicated as 7, shows one side of the film (the first side 15) is folded over the second side 16 of the film 2, thereby encapsulating the wires 4, 6 within a double layered folded film 8 as shown in Figure 4. Here the first side 15 becomes the top layer of the film 8 and the second side 16 the bottom layer of the film 8.

The resulting folded film 8 with encapsulated wires 4, 5 is then drawn between two hot rollers 9. The hot rollers preferably have a surface temperature of approximately 90°C and one roller is formed from aluminium, while the other is formed in silicon coated aluminum. The hot rollers 9 are driven by a motor (not shown) that provides a force that pulls the film 2 and wires 4, 5 off their spools 1, 6 and draws the film 2 and wires 4, 5 through the film folder 3. The heat from the rollers 9

cause the film 8 to become soft (as the rollers temperatures are close to the film's melting temperature) and the pressure exerted by the rollers on the folded film cause the folded sides of the film to be fused together, permanently encapsulating the wires therein. The hot rollers 9 each have two grooves machined into their surfaces, preferably approximately 1 millimetre apart. These grooves provide a guidance of the wires 4, 5 to force the wires to be spaced within the folded film 8, 1 millimetre apart.

It is preferred in the manufacture of folded film 8 that the film folder 3 is positioned so that the fold X runs on one of the grooves of the hot rollers 9 forcing the first wire 5 into the fold X and the second wire 4, 1 millimetre away from the fold X. Furthermore, the film folder 3, must be positioned so that uneven film overlap is prevented. Such positioning of the film folder 3 is very critical to produce good quality film. In other forms of the film of the present invention the wires may be located at a distance from the fold or at different distances from one another.

The folded film 8 is then drawn from the hot rollers 9 and passed through a film creaser 10. The film creaser 10 is two rollers, one of which has a v-shaped edge which creates the crease 12 in the folded film 8, as shown in Figure 5. The crease 12 is formed in the folded film 8 subsequent to the hot rollers 9 as the folded film 8 is still soft and less force is required to form the crease 12 in the film 8. The crease 12 is preferably formed midway along the width of the film. The crease 12 has the purpose of encouraging the film 13 to fold in a certain position and orientation, which assists in the forming of the conduit of the present invention that is described below. The folded and creased film 13 is then uniformly drawn onto a finished film spool 14.

Reference is now made to Figures 2 and 10. As the folded film is still soft when is comes out of the film creaser 10, the tension of the folded film 8 has to be controlled accurately so that the folded film 8 is not stretched thinner or narrower. Therefore, the film 8 is drawn through at least one tension roller 11, although more than one roller may be used. As shown in Figure 10, two tension rollers 40, 41 are provided that are attached to an arm 42 and controlled by a position sensor 43, such that if the rollers 40, 41 are not in a correct position to provide the correct tension in the film 8, the rollers 40, 41 are adjusted in order that the correct film tension. The rollers 40, 41 are attached

to an arm 42 that rotates about a pivot point 44 moving the rollers 40, 41 up or down. When the tension of the film 8 increases and more force is placed on the rollers 40, 41 and arm 42, the arm 42 moves upwards out of the correct tension position, this position preferably being a central position (as shown on Figure 10). The position sensor 43 located near the arm 42 detects the movement of the arm and causes the motor drawing the film through the rollers and onto the finished film spool 14 to decrease its speed, consequently reducing the pull on the film 8 through the tension rollers 40, 41. Conversely, if the position sensor 43 detects the movement of the arm 42 downwards out of the central position due to a reduction in the film tension, the sensor 43 causes the motor to increase its speed causing the film 8 to be drawn more quickly through the rollers 40, 41. Thus, the position sensor 43 and motor control the speed of the film 8 through the tension rollers 40, 41 and thus the tension of the film.

In other forms of the preformed film of the present invention a film may be formed that does not have the conductive wires encapsulated within it. This form of the film could be used in conduits not requiring heating elements.

Conduit Forming

A conduit that is formed using the preformed film as described above will now be described. To manufacture a heated conduit a preformed film having at least one encapsulated conductor would be used. To manufacture a non-heated conduit a film without any conductive wires or other conductive material would be used. The description below does not distinguish between a film with or without the conductive material. Therefore, when "film" is referred to below it must be appreciated that either a film containing conductive material or one without conductive material is being referred to.

Figure 7 illustrates a conduit 17 formed from a film as described above and using the conduit forming method as described below. The conduit may be used as a transport path supplying gases to a patient and has a thin film flexible wall. The film, such as the preformed film described above, is arranged in a spiral or helix such that the edge portions of adjacent layers overlap and form the wall 18 of the conduit or tube 17. A bead 19 of polymer material is extruded over the overlapping portions of

adjacent winds of film to bond the overlapping portions of film to form a continuous conduit or tube 17.

Figure 6 illustrates a similar conduit to that of Figure 7, but one that has integral conductors formed into the conduits wall. Figure 6 shows a cross section of a folded film 20 including two encapsulated conductive wires 29, 30. The bead 19 is extruded over the overlap of the upper layer 32 (having the encapsulated conductive wires 29, 30) and the lower layer 31 of the film 20. The molten bead 19 bonds the two layers together. In the next wind of the film 20, the other end 33 (not having any wires) of the upper layer 32 becomes the new lower layer 33 that is bonded with the new upper layer 34. With consecutive turns of the mandrel 24 and film 20 a conduit is formed with smooth inner walls.

An example of the forming apparatus suitable for manufacturing the conduits of Figure 6 or Figure 7 is shown in Figures 8 and 11. Figure 9 illustrates the steps in the conduit forming process of the present invention. Reference is made to Figures 8, 9 and 11. The spool 14 of preformed film as described above is mounted onto a frame (not shown) of the conduit forming apparatus. The film 20 is drawn from the spool 14 through various tension pads and rollers 21, then through pinch rollers 22. Next the film passes through at least one tension roller 23 and is fed onto a mandrel 24.

The mandrel 24 includes a former, preferably of a known type, including a plurality of rotating rods or cables arranged around a central support rod. The rods or cables extend from and are rotated by a gearbox within a machine stock 26. At least in the conduit forming region the rotating rods follow a helical path. The pitch angle of the rods relative to the support rod controls the pitch angle of the conduit being formed. An example of such a mandrel is a spiral pipeline mandrel available from OLMAS SRL of Italy.

The conduit being formed on the former is rotated and advanced in the direction of arrow 27 by the movement of the rotating cables. The advance speed of the former is selected relative to the rotational speed of the cables and is dependent on the pitch of the helical laying of the film on to the former, such that adjacent turns of the film narrowly overlap. The spool 14 of preformed film 20 as described above is eventually

fed (after being fed through tension rollers and the like, as described above and in more detail below) onto the former (mandrel 24) in a helical fashion by action of the former. The pitch of the helical disposition of film 20 is slightly less than the width of film 20 and results in an overlap of approximately 2 millimetres. The helical deposition of film 20 forms the wall 18 of the conduit shown in Figure 7. An extruder 28 extrudes the bead 19 of polymer material onto the overlap of the film 20 winds. The rotating mandrel 24 draws the molten bead 19 over the overlapping portions of adjacent winds of film 20 and is sufficiently heated to weld to the layers of film 20. In the preferred embodiment of the present invention the bead 19 is extruded at 250°C providing enough heat to thermally bond the layers of film together. The conduit formed according to this method has an approximate internal diameter of 19 millimetres.

In the form of the conduit where the conduit is heated and has encapsulated conductive wires (see Figure 6), the extruder 28 is positioned so that the bead 19 is drawn on to the correct position to completely bond the overlapping film together and to hide the wires. In both the heated and non-heated conduits the bead 19 shape is such that to assist in the forming of the conduit. The bead 19 as shown in Figures 6 and Figure 12, is concave 37 nearer the middle of its underside, and the sides of the underside 38, 39 are relatively angled out to the edges of the bead 19 in a straight manner. The concave 37 shaped underside helps to provide some guidance of the laying of the bead 19, as the bead 19 tends to follow the two bumps created by the wires in the film 20. The straight sides 38, 39 of the underside of the bead help to keep the film 20 flat and become almost horizontal during the forming process. The bead 19 also has two arced sides 35, 36, which help the bead edges bond to the film. If the conduit thus formed was contracted longitudinally the crease 12 formed in the film 20, as shown and described in relation to Figure 5 would tend to cause a folding in the conduit upwards between the bead 19 and moves the film out of the gases path through the conduit, when the conduit is in use. The bead width and height are chosen to give an adequate crush strength and to allow enough space for the film to fold upwards between the bead, while retaining its general shape and proportions.

Referring back to Figures 9 and 11, the frame of the conduit forming apparatus of the present invention has many degrees of freedom to allow for the adjustment of the angle that the film 20 is fed onto the mandrel 24. The frame includes a set of set of pinch rollers 22 mounted thereon, which pull the film 20 from it's spool 14, through at least one tensioning pad and around at least one roller 21, which are also mounted on the frame of the conduit forming apparatus. The film 20 is then fed around at least one tension roller 23 and then onto the mandrel 24.

The difference in speed between the pinch rollers 22 and the cables on the mandrel 24 creates the tension in the film 20. The film tension is important to maintain the stability of the film 20 on the mandrel 24 and also if the tension is too high, the film will not fold upwards between the bead 19.

The tension roller 23 is controlled by a sensor 45 and arm 46, such as that described above in relation to the preformed film method described with reference to Figure 2. In the case of the conduit forming, if the tension in the film 20 increases the roller 23 (attached to the arm 46) and arm 46, pivoting about a pivot point 47, move upwards in the direction of arrow A. The position sensor 46 senses the change in position of the arm 46 and thus roller 23 and the motor driving the pinch rollers 22 increase the speed at which the film 20 is drawn from the spool 14 and the tension in the film 20 reduces causing the roller 23 and arm 46 to move back to the central position as shown in Figure 11. Conversely, if the tension of the film 20 decreases the arm 46 and roller 23 move downwards in the direction of arrow B. The position sensor 45 senses this change in position and causes the motor driving the pinch rollers 22 to decrease the speed at which the film 20 is drawn from the spool 14. The sensor 45, pivotable arm 46 and roller 23 ensure that a constant tension of the film is maintained so that the film 20 being winded onto the fixed speed mandrel 24 has a constant overlap.

In the preferred form the mandrel 24 has air or water cooling to cool the conduit as it is formed on the mandrel 24 and to ensure that the bead 19 does not melt through both the lower layer 31 and upper layer 32 (see Figure 6) of the film 20. As the bead 19 is extremely hot when it is extruded onto the film 20, air cooling is required, both

internal and external to the conduit being formed, to prevent the film from being melted and/or damaged. The internal air cooling is provided by having hypodermic stainless steel tubing on the mandrel, which sprays several fine jets of air onto the inside of the tube. The external air-cooling is provided by a series of air knives that spray a blade of air onto the outside of the tubing.

The mandrel 24 will now be described in more detail. The mandrel 24 has six stainless steel speedometer cables, all of which are rotated at the same speed. The speedometer cables are located in the mandrel 24 within undercut grooves, which have been machined into the stainless steel mandrel in a helix with a specified angle. The mandrel 24, preferably made of stainless steel, has scallops machined into it between the speedometer cable grooves to provide a clearance so that the film 20 rests on the speedometer cables, rather than the mandrel 24. A groove is also machined into the centre of these scallops to provide a space to place tubing for internal air cooling. The stainless steel mandrel may also be water cooled with monitoring of the water flow rate, to ensure that there is sufficient cooling.

The speedometer cables provide the drive to pull the film 20 onto the mandrel 24 as described above. The helical angle of these cables is important to create the correct amount of overlap of the film 20. With the angle of the cables set at 6.6 degrees to the horizontal, the film 20 is drawn onto the mandrel 24 and is wrapped around it in a helix as described above. The set angle causes the film to overlap by approximately 2 millimetres. The amount of overlap of the upper layer 32 and lower layer 31 is critical, because if the overlap is too much (i.e. wider than the extruded bead 19), lower layer 31 will not be completely bonded to the upper layer 32 of the film, thereby creating a loose edge inside the formed conduit wall 18, which can cause a reduction in the performance of the conduit and creates a crevice for bacteria to grow. If this overlap is insufficient, during conduit forming, the film 20 becomes unstable and tends to slip, and the conduit thus formed will not be formed with continuous walls.

In particular, with reference to Figure 6, it is important that there is an overlap of the film layers 31, 32 where the wires 29, 30 are on the upper layer 31, so that there are three layers of film between the wires and inside the conduit. This prevents the

wires from being melted out and exposed on the inside of the conduit, and provides a thicker surface to retain the wires for increased durability. The angle of the film being fed onto the mandrel ensures a conduit is formed with a particular pitch, which has been found to give a good compromise between the crush strength and the amount of film between the bead.

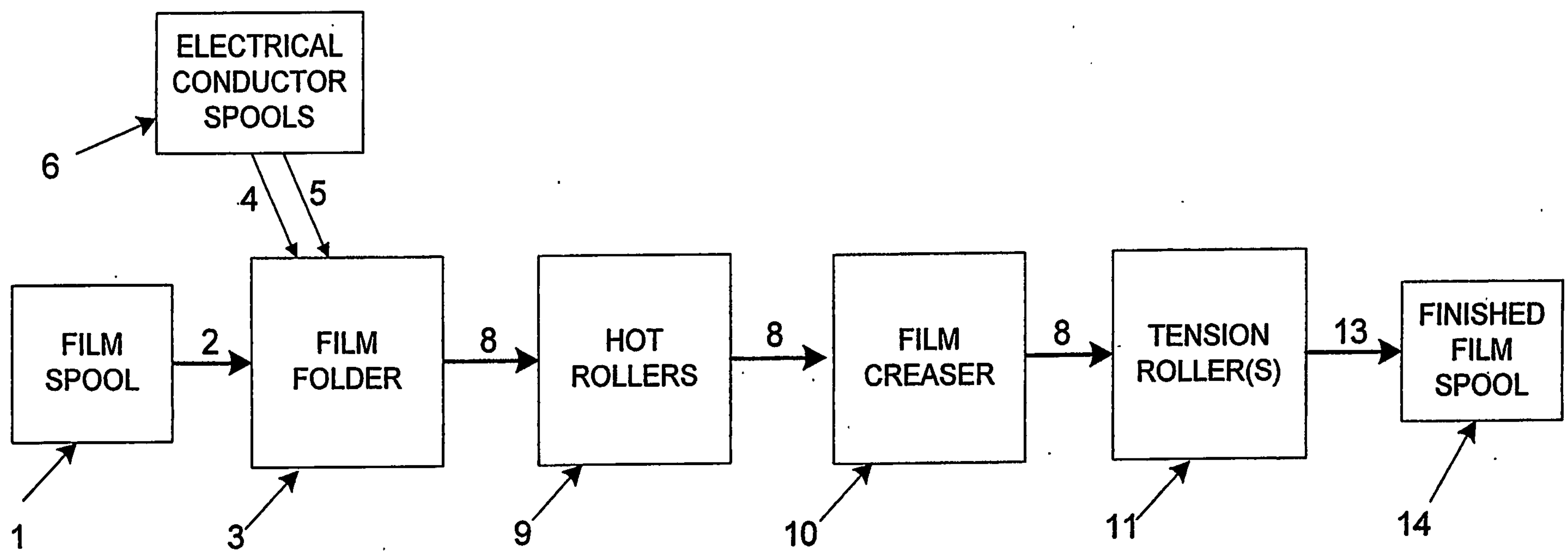
The method of preforming the film of the present invention could be extended to include additional folding of the initial film to produce films of more layers. Alternatively, more than one film could be used in the formation of the conduit of the present invention to increase the thickness of the conduit wall and thus the walls strength, yet still providing a conduit that is flexible.

Heated conduits formed by the method described above may reduce the build up of condensation in the conduit and may also offer a means to maintaining the temperature of humidified gases flowing through the conduit. Heated conduits are used as gases transportation pathways in applications such as for Continuous Positive Airway Pressure (CPAP) therapy. In such conduits where the pathway includes conductive wires to heat gases flowing through the pathway, the corresponding connectors, at least at one end of the conduit, will include an electrical connection suitable for connection with the humidified gases source in order to supply electrical energy to the conduit heater wires.

DATED THIS 31st DAY OF October 2002
AJ PARK
PER N Shelley
AGENTS FOR THE APPLICANT

Figure 1

PRIOR ART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6
4
5
FILM SPOOL
2
FILM FOLDER
8
HOT ROLLERS
8
FILM CREASER
8
TENSION ROLLER(S)
13
FINISHED FILM SPOOL
1
3
9
10
11
14

Figure 2

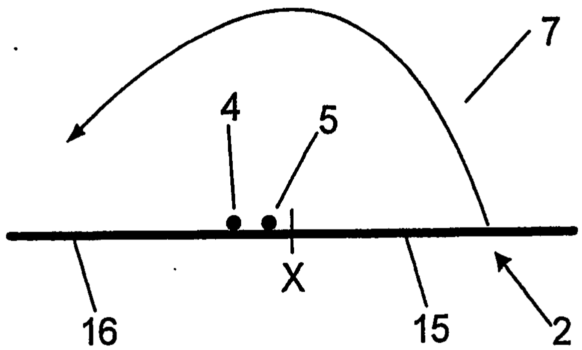

Figure 3

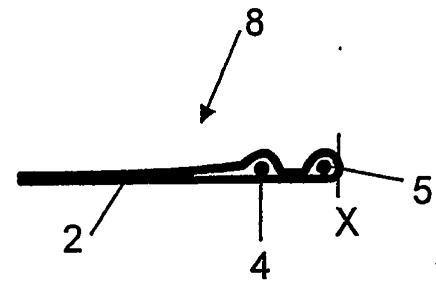

Figure 4

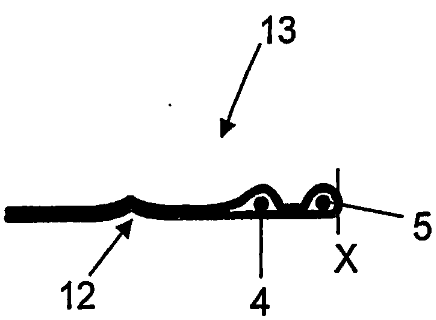

Figure 5

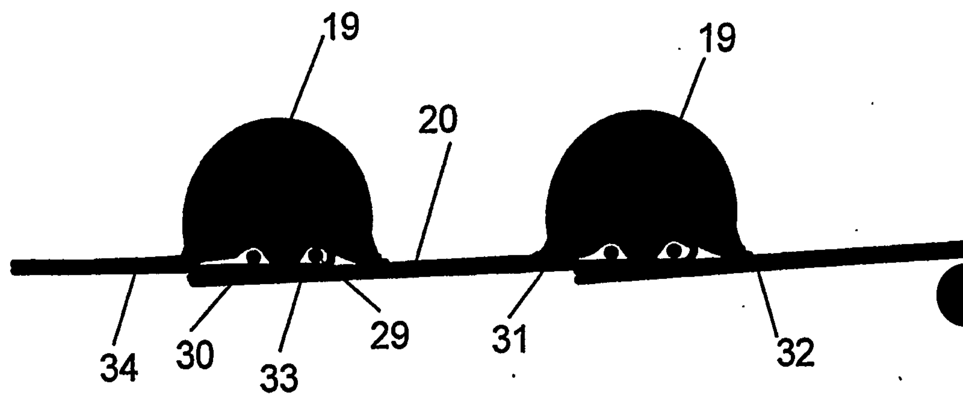

Figure 6

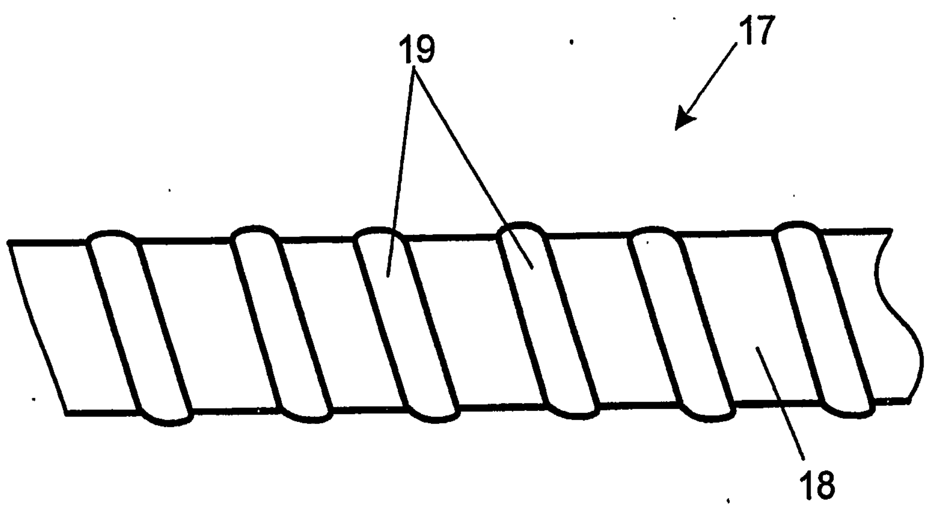

Figure 7

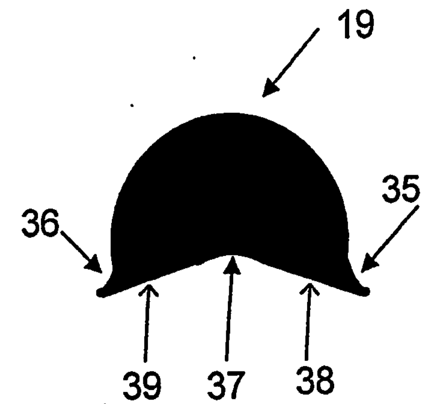

Figure 12

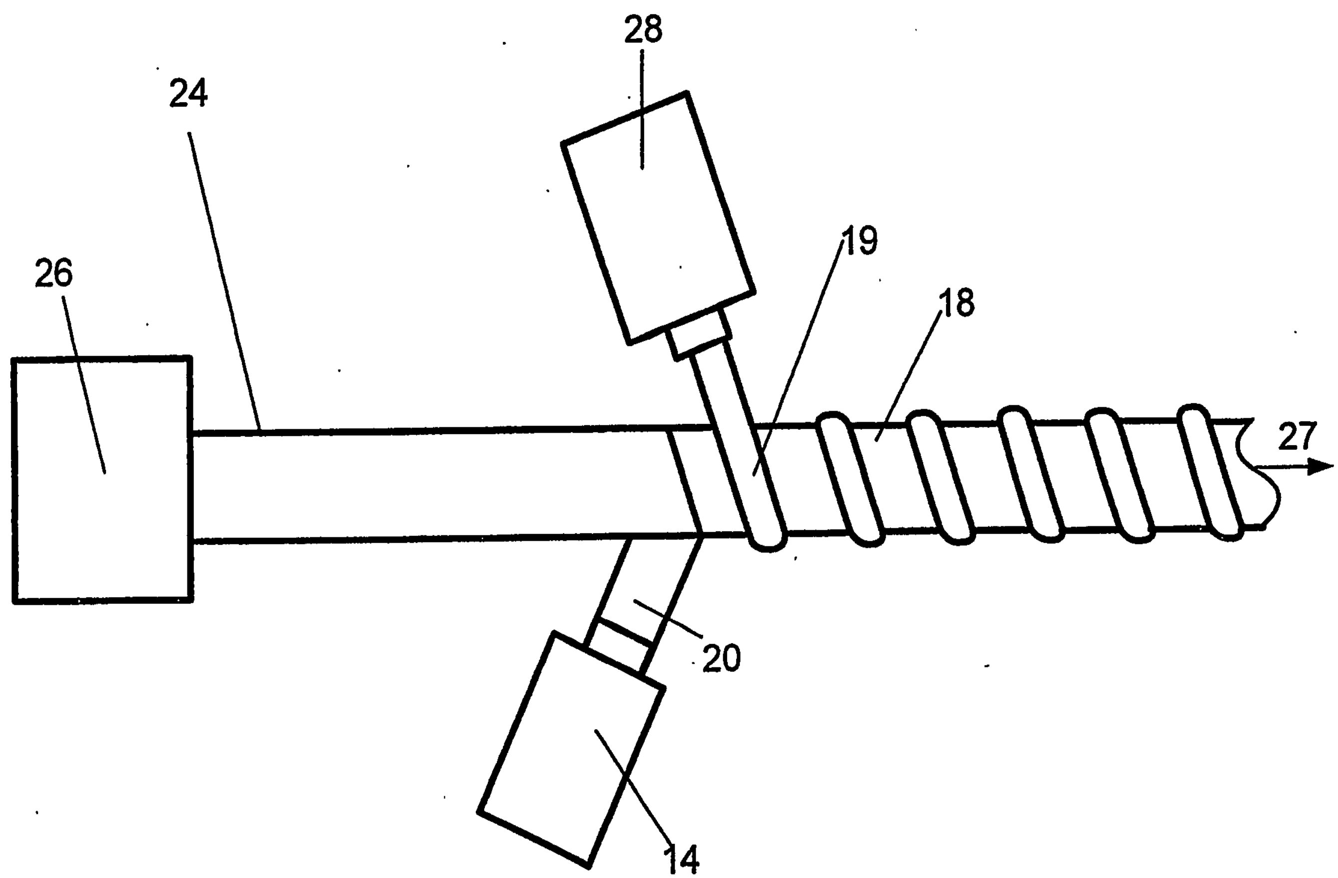

Figure 8

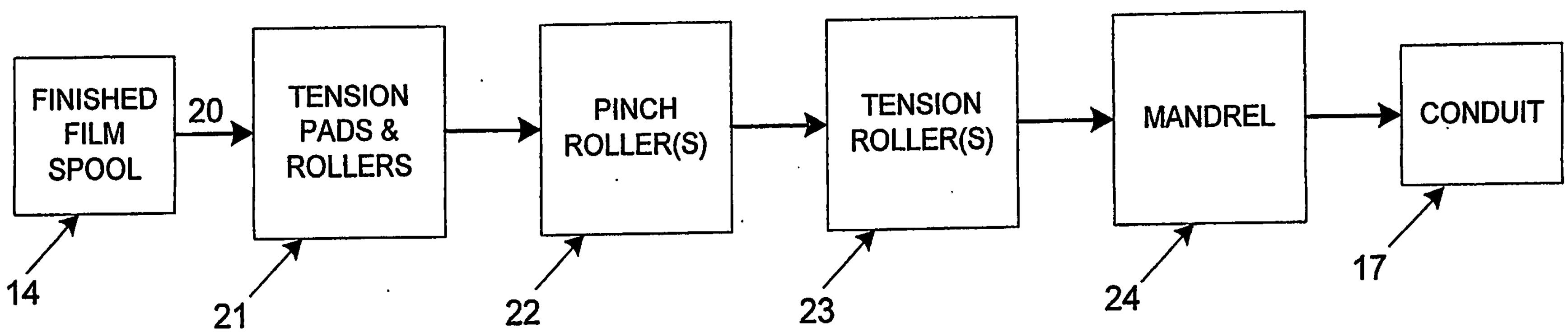
FINISHED FILM SPOOL
20
TENSION PADS & ROLLERS
PINCH ROLLER(S)
TENSION ROLLER(S)
MANDREL
CONDUIT
14
21
22
23
24
17

Figure 9

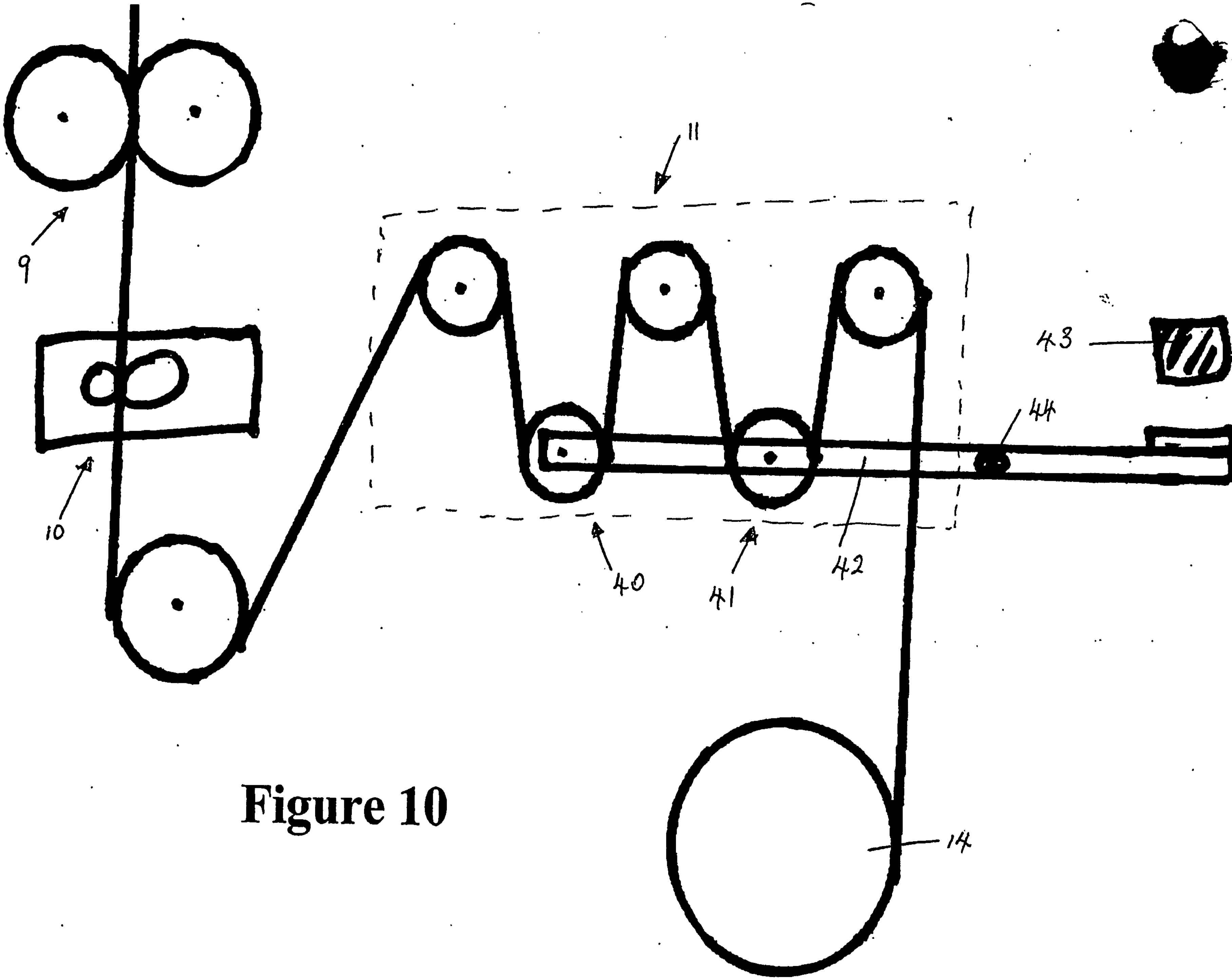

Figure 10

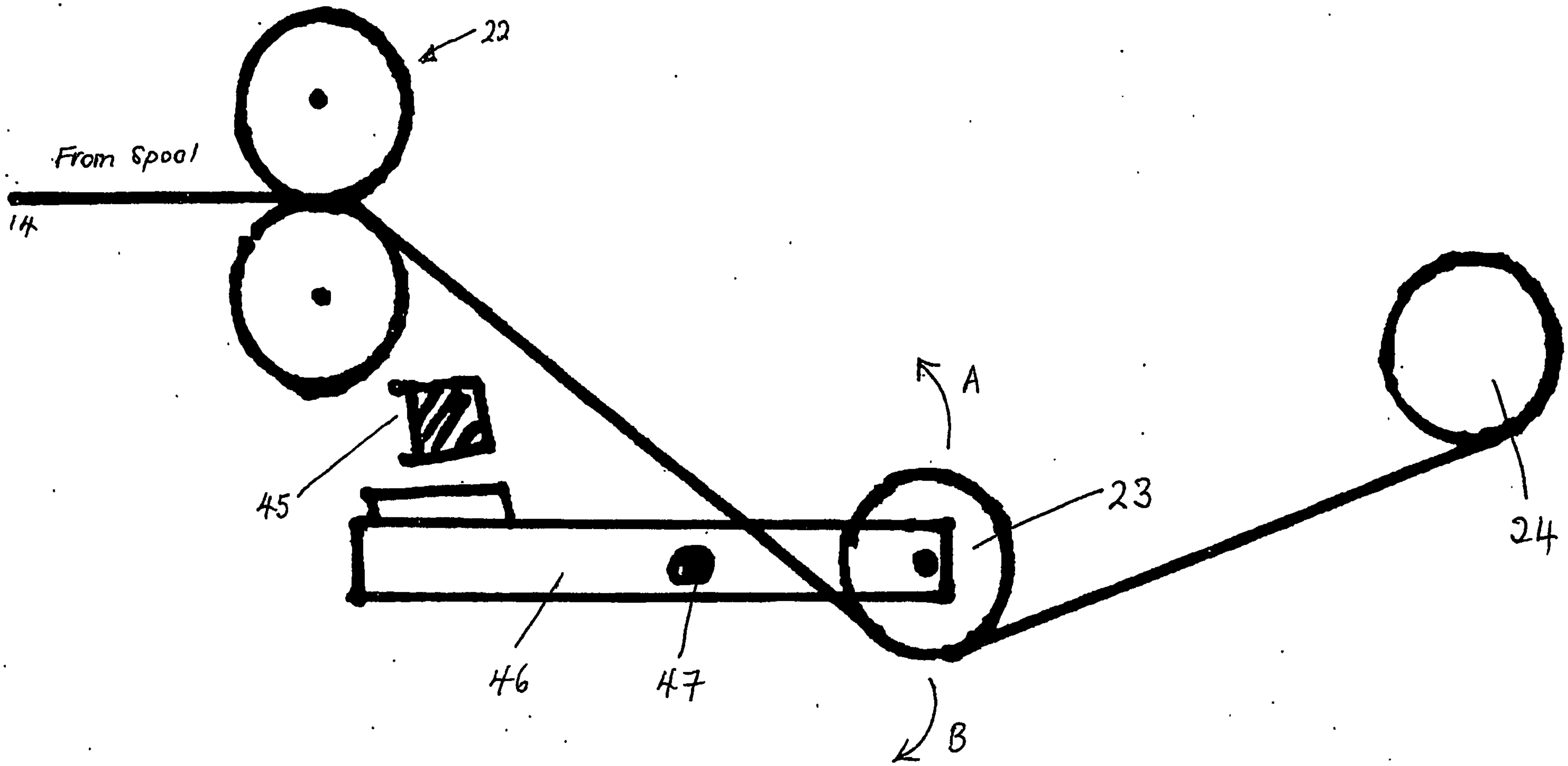

Figure 11

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